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WHAT IS THE PURPOSE OF THIS REQUIREMENT?

There is a saying in construction that a project can be finished on time, on budget, or 100% complete: pick any two. Commissioning significantly increases the likelihood that technical details such as system configurations, HVAC air and water flow rates, occupancy and temperature settings, and the record drawings are correct and complete. Getting these technical details right can have a significant impact on the long-term performance of the building systems. However, these types of details are often not addressed until the end of a project when time is short and budgets are nearly spent. Commissioning requirements in the WSEC elevate the priority for this important step in the construction process.

WHAT VALUE DOES IT PROVIDE TO THE OWNER?

Commissioning according to the WSEC supports the owner and the general contractor by helping them get what they paid for, particularly at the end of a project. A commissioned project has fewer occupant complaints and higher occupant comfort. The equipment in a commissioned project has improved longevity and is more likely to operate efficiently. Many corporations and Washington institutions find commissioning so valuable that they require all of their construction projects to be commissioned.



Organizations that require commissioning

- > Washington state buildings (GA)
- > Washington public schools
- > University of Washington facilities (UW)
- > Military facilities
- > Federal buildings (GSA)
- > Any project that is seeking a LEED Green Building certification

Cost benefit analysis of commissioning

A 2009 study by Lawrence Berkeley Laboratory found that commissioning has a payback of 1.1 years in existing buildings.¹

¹ Cost Benefit Analysis of Commissioning:
<http://evanmills.lbl.gov/pubs/pdf/cx-enef-mills.pdf>

HOW DOES IT SAVE ENERGY?

The WSEC requires system balancing, sensor calibration, and operational testing that are completed at the end of project. When these steps are skipped or done incorrectly the impacts to system performance may not be initially apparent. Instead, the owner and operating personnel may experience indirect indicators over time such as complaints about the lighting in a daylight area or an inability to maintain the space temperature in a particular zone. Without complete testing documentation, the root cause of these issues may be difficult to identify. Troubleshooting can be costly and time-consuming, and may lead to override of controls. Systems that are not operating as designed per the WSEC requirements often have higher energy consumption than if the required technologies were excluded from the project altogether.

The Commissioning Process

The WSEC defines commissioning as “a process that verifies and documents that the selected building systems have been designed, installed, and function according to the owner’s project requirements and construction documents, and to minimum code requirements.” Put another way, the WSEC requires most construction projects to set aside some of the project schedule and budget to create a written testing plan and then to execute this plan prior to the end of the project. This commissioning plan is designed and executed by a team chosen by the building owner; it is not an inspection performed by the jurisdiction. Typically, the contractor installing the equipment is part of the commissioning team as well as the general contractor, building operations personnel and the commissioning professional. A key aspect of the WSEC commissioning requirements is that they are tied directly to a construction project, whether it is an addition, a retrofit, or a brand new building.

The Commissioning Plan

The WSEC supports owners by listing what is required to be in the commissioning plan. The intent of this plan is to communicate a written quality assurance process that the commissioning team completes together. To be effective, the level of detail in the commissioning plan reflects the complexity of the project. For example, a commissioning plan for a new construction project may cover mechanical systems, lighting controls, domestic service water equipment, and an energy metering system. This type of plan may include a wide variety of commissioning team members and multiple functional testing processes. On the other hand, a mechanical system replacement project may include just a few team members and only covers the affected mechanical system(s). Section C408.1.2 in the WSEC requires the following in the commissioning plan:

- > A list of the commissioning team personnel, including each person’s commissioning responsibilities
- > A narrative description of the commissioning activities
- > A schedule
- > A listing of the specific equipment or systems to be tested and a description of the tests to be performed.
- > Description of the testing including functions to be tested, conditions under which the test will be performed, and measurable criteria for performance.
- > Disclosure and conflict management plan, if required.

Conflict Management Plan

Many types of companies employ commissioning professionals and these companies can offer multiple services to the same project. For a project where the commissioning professional is an employee of one of the project design firms or contractors, an In-House Commissioning Disclosure and Conflict Management Plan is required within the commissioning plan. This plan discloses the commissioning professional’s contractual relationship with other team members. It explains the process that assures the commissioning professional is free to identify any issues discovered and report this information directly to the owner.

Building System Retrofit Commissioning

Commissioning requirements in the WSEC apply to existing mechanical systems, lighting controls and energy metering equipment that are altered or replaced with new equipment. The scope includes system elements that are directly affected by the retrofit. Equipment repairs are not required to be commissioned. Note that commissioning applicability thresholds in the WSEC are based on the total capacity of all systems in the building, not just the capacity of individual pieces of equipment. Therefore, the commissioning requirements *do* apply to retrofit equipment and systems that are smaller than the thresholds *if* the total capacity of all systems in the building exceeds these thresholds.

Commissioning was incorporated into the WSEC in 2000, so in many cases existing equipment and systems were not commissioned. The retrofit commissioning process provides the opportunity to optimize the affected systems to a higher level of performance than prior to the retrofit. It also ensures the new equipment is correctly integrated with other existing-to-remain systems.



Commissioning Completion and Certificate of Occupancy

The commissioning process is closed out with a report. The report verifies that all planned commissioning activities were completed, states all applicable findings, and lists any recommendations for further work. To certify that a project has met the WSEC commissioning requirements, a copy of the Commissioning Compliance Checklist is submitted to the jurisdiction prior to final inspection. The Checklist is a one-page form found within the WSEC Section C408. The commissioning process itself is not an inspection item by the jurisdiction. However, the inspector may request a copy of the commissioning report as evidence that the required commissioning activities have occurred prior to issuing a certificate of occupancy.

WSEC requirements include preliminary and final commissioning activities and documentation. For small retrofits, all required preliminary and final commissioning activities will likely be finished concurrently with or prior to final inspection. For large or complex projects, the WSEC recognizes that commissioning is an on-going process that often continues post occupancy. Therefore a preliminary report stating all findings at the time of final inspection is sufficient evidence for WSEC compliance. The preliminary report is required to list any deficiencies related to the energy code that are not corrected at the time of the report. This includes a description of any deferred testing and the status of the project's record documents, manuals, and operator training. The final commissioning report is submitted to the owner upon completion of the commissioning process, but is not required to be submitted to the jurisdiction.



Who Can Perform Commissioning Services?



The 2015 WSEC requires that a *certified commissioning professional* perform commissioning services. Qualified individuals have received certification through an approved accrediting organization per ANSI/ISO/IEC 17024:2012. A licensed professional engineer in Washington state may also perform WSEC required commissioning services. If the individual assigned to oversee and perform these services for a project is the Engineer of Record, an employee of the Engineer of Record, or an employee of the installing contractor, a Conflict Management Plan is also required.



Additional Commissioning Services

Re-commissioning and existing building commissioning - these terms refer to services performed after the completion of a construction project. These services are not governed by the WSEC. Some Washington state utilities provide rebates or incentives to help owners go through these types of commissioning processes. For example, the owner of a retail center who plans to put their building on the market may choose to tune up their existing systems to potentially increase the re-sale value of their building. They can contact their electric utility company or engage with a qualified service provider to commission their existing building. If the facility has never been commissioned before, the service provider might refer to the process as "existing building commissioning." If the facility was commissioned during original construction, then the term "re-commissioning" is appropriate. The main difference between these services is that re-commissioning is based on the results of the previous commissioning process.

Typical commissioning team members and responsibilities

> Building Owner and Building Operations

Personnel – The best advocates for commissioning are those who will own and operate the building. Key elements for a successful project include project scope defined by the owner that provides clearly defined and measurable system operation goals. Equally important are requirements for written instructions, hands-on system operation training of building operations personnel, and complete record documents. To facilitate a collaborative process, the owner requires in the project scope that all project team members coordinate with the commissioning team as needed.

> **Design Team** – A design that supports the commissioning process includes information that explains how each system is intended to operate under all anticipated conditions. In addition, systems are configured to facilitate the necessary testing procedures. The design team then states within the construction documents that WSEC required commissioning shall be included in the construction scope for all elements and systems required to be commissioned.

> **General Contractor** – Incorporating commissioning activities into the construction scope and schedule ensures that sufficient time and budget are allocated when needed. It is important that the general contractor is aware of commissioning milestones in the construction schedule. This facilitates proactive coordination with the commissioning team to bring them in at optimal times in the schedule

to complete various phases of testing and review. Training of building operations personnel when commissioning testing procedures are complete is also included in the construction schedule. Most often the general contractor is responsible for submitting a WSEC Commissioning Compliance Checklist to the authority having jurisdiction.

> **Sub-Contractors** – Commissioning milestones in the general construction schedule alert all installing sub-contractors that they need to include commissioning-related scope in their bids and work schedules. This includes time with technical personnel to perform system functional testing and to provide training of building operations personnel. Subcontractors are also required to provide complete record documents and operations and maintenance manuals in a timely manner.

> **Commissioning Professional** – An individual who leads, plans, and oversees the commissioning process. The commissioning professional receives input from the owner, develops the commissioning plan (either during design or during construction), and develops and/or approves written functional test forms. He or she works with the General Contractor and Sub-Contractors to plan and schedule functional testing, oversees functional testing, analyzes test results, determines whether systems are operating per WSEC requirements, and recommends equipment and system acceptance to the Owner. The commissioning professional develops the commissioning report and completes the WSEC Commissioning Compliance Checklist.

Project Close Out Documentation

The WSEC requires that construction documents be provided to the building owner within 180 days of receipt of the certificate of occupancy. This includes record documents, O&M manuals and compliance documentation. O&M manuals are required for all systems, equipment, components and devices in the project that are governed by the WSEC, regardless of whether they are required to be commissioned.

Information required within the O&M manuals include:

- > Brief narrative explaining how each system is intended to operate
- > Recommended setpoints and calibration information
- > Wiring diagrams, schematics and control sequences
- > Routine inspection and maintenance actions and recommended schedules
- > Contact information for at least one service agency.

In addition to documentation, the WSEC also requires training of building operations staff. Hands-on demonstration of how to perform all normal maintenance procedures, how to check equipment operating modes relative to recommended settings, and procedures for emergency shutdown and start-up, increases the likelihood that systems and equipment will function optimally over time.



When is WSEC commissioning required?

The WSEC requires commissioning for many different types of projects including additions and retrofits. The table below describes thresholds for system capacity and complexity that, when exceeded, trigger the commissioning requirements. It also summarizes the types of equipment and testing procedures that are required.

	Commissioning Thresholds	Examples of Commissioned Systems
C408.2 Mechanical and Refrigeration Equipment and Controls	<p>Per Building Threshold: For mechanical systems, total installed building capacity is equal to or greater than 240 kBtu/h (20 tons) of cooling or 300 kBtu/h of heating. For refrigeration systems, total installed building capacity for refrigeration is equal to or greater than 240 kBtu/h.</p> <p>Per Unit Threshold: All mechanical systems included in the project, and all refrigeration systems with remote compressors and remote condensers included in the project – no individual capacity minimum.</p>	Configuration settings and operation of HVAC equipment, economizers, and controls.
C408.3 Lighting Controls	<p>Per Building Threshold: Total installed building lighting load is equal to or greater than 20 kW. Qualifier – If lighting load is less than 20 kW, but 10 kW or more of this load is controlled by occupancy sensors or automatic daylight controls, commissioning is required.</p> <p>Per Unit Threshold: All automatic lighting controls included in the project.</p>	Control functions & configuration settings for occupancy sensors, time switches, and daylight responsive controls.
C408.4 Service Water Heating	<p>Per Building Threshold: Capacity of the largest service water heating system in the building is 200 kBtu/h or greater. Qualifier – Commissioning is required for all service water heating systems serving pools or permanently installed spas, regardless of equipment size.</p> <p>Per Unit Threshold: All service water heating systems included in the project – no individual capacity minimum.</p>	Control functions & configuration settings of central service water heating systems, pumps, and controls.
C408.6 Energy Metering	<p>Per Building Threshold: Buildings over 50,000 SF with gross conditioned floor area of at least 25,000 SF, and additions over 25,000 SF, that were subject to the metering provisions at the time of initial permit.</p> <p>Per Unit Threshold: All metering devices and systems included in the project.</p>	kWh meters, natural gas meters, connection to energy source meters, data collection system.

Technical content contributed by:



SAMPLE COMMISSIONING PLAN FOR MECHANICAL RETROFITS

1. General Project Information

Project Name	Adams Office Park - HVAC Equipment Replacement
Project Address	123 Jones Ave NW
Building Type	Commercial
Building Size (ft2)	19,500
Scheduled Completion Date	February 2017
Project Scope	Replace AHU-2 and AHU-3 on Building 2 with two new packaged rooftop air handlers with heat pump cooling and heating. Total cooling capacity of new equipment is 540 kBtu/h (45 tons). Integrate new equipment controls with existing control system and recalibrate zone controls. Rebalance existing air distribution system.

2. Commissioning Goal: Perform commissioning tasks consistent with WSEC Section C408 and verify operational compliance with applicable WSEC provisions.

3. Commissioning Team Information

Role	Name	Company
Owner / Facility Manager	John Smith	WA Building Management, Inc. (WBM)
Commissioning Professional (CxP)	Julie Wilson ¹	Venture Mechanical
Mechanical Design Build Engineer	David Anderson	Venture Mechanical
Mechanical Contractor	TBD	Venture Mechanical, authorized factory Start-up Technician
Air system balancer	TBD	Venture Mechanical

¹ As of July 2016, Julie Wilson has been a commissioning professional for 5 years. She has commissioned 10 projects and has been certified by the Building Commissioning Association at a Certified Commissioning Professional (CCP). Since Julie works for the same company as the design engineer and as the installing contractor, there is potential for a conflict of interest to occur. To mitigate this concern, the Venture Mechanical contract includes an In-House Commissioning Disclosure and Conflict Management Plan that identifies both Julie and David as points of contact with WBM, Inc. In addition, Julie has a contractual requirement to report all commissioning findings directly to John Smith, the project owner.

4. Commissioning Process: Activities, Schedule, and Responsibilities

Commissioning (Cx) Activity	Project Phase & Jurisdiction Submittal	Responsibility	Notes
Cx Plan	Design Phase	CxP	This document. Include a brief narrative of the required Cx activities, schedule of when Cx activities are to be performed and a list of required record documents, O&M manuals and systems operation training.
Develop start-up and functional test procedures	Design Phase	CxP	Provide start-up checklists, air system testing and balance forms (TAB), and functional performance test procedures for recording test results. Include criteria for acceptable performance per the mechanical design for all equipment and systems to be tested. Cx documents are reviewed by the engineer.
Cx information to AHJ	Permit Submittal	Engineer	Include Cx Plan and test procedures.
Cx kick-off meeting (combined with mobilization/pre-construction meeting)	Construction Phase	Lead by CxP	Review commissioning requirements and schedule with Owner. Provide copy of all start-up and testing forms to the owner for review, comment, and approval.
Complete start-up checklists	Construction Phase	Contractor and CxP	Contractor completes and signs checklists indicating that installation and balancing is complete for each system being commissioned and that the system is ready for testing. CxP reviews completed checklists.
Perform functional testing	Construction Phase	Contractor, CxP and Owner witness	Contractor executes tests under guidance of CxP. Deficiencies are noted by CxP and reported directly to the Owner who witnesses the testing. Retesting is performed after deficiencies are corrected, as needed.
Retrofit Cx report (preliminary & final) to AHJ	Cx Report Submittal / Mechanical Inspection	CxP	Provide CxP certification of acceptance form (e.g. WSEC Cx Compliance Checklist). Include in Cx report: executed checklists, completed functional test forms, a record of deficiencies with resolutions and remaining unresolved issues, deferred tests and conditions required to complete them, and the status of record documents, O&M manuals and systems operation training.

5. Summary of functional tests and acceptance criteria

Functions to Test	Measureable Criteria for performance
Using the existing building controls, test each mode of operation including startup, cooling, heating, auxiliary heat, shutdown & power failure.	<ol style="list-style-type: none"> 1. The HVAC unit components respond appropriately to changing conditions and parameters within the specified performance range according to acceptable operating practice and as required by WSEC mandatory provisions. 2. Confirm that the HVAC unit fault detection and diagnostics (FDD) system provides the correct system status during each mode per C403.2.4.7.
Using the existing building controls and distribution system, test AHU economizer mode.	<ol style="list-style-type: none"> 1. HVAC unit varies airflow during economizer mode per C403.2.11.5. 2. Economizer control is integrated with mechanical cooling as required per C403.3.1 and C403.3.3. 3. Economizer high limit shutoff meets requirements of C403.3.3.3. 4. Economizer relief air and dampers comply with C403.3.3. 5. Minimum ventilation airflow complies with the International Mechanical Code.
Confirm setback and setup temperatures, and automatic start schedules, for all zones included in the project.	<ol style="list-style-type: none"> 1. Difference between cooling and heating temperature setpoint (deadband) is at least 5 degrees per C403.2.4.1.2. 2. Automatic setback and shutdown controls are programmed to comply with Section C403.2.4.2. 3. Automatic start controls are programmed to adjust daily start time per C403.2.4.2.3, based on occupancy schedules provided by the owner.
Observe how HVAC unit operates over time (economizer, cooling, heating, deadband).	Heat pump goes out of heating mode, through deadband, into economizer and then mechanical cooling mode, and back again without system hunting, short cycling, alarms or errors.
Cause alarms and FDD fault to occur at the HVAC unit.	The FDD reports the alarm correctly and HVAC unit controls to go into alarm mode, as indicated in the construction documents and/or manufacturer's instructions.
Verify up to 10% of the TAB report data. TAB contractor executes the checks, witnessed by the CxP, using the same test instruments that were used in the original TAB work.	A failure of more than 10% of the selected items of a given AHU system shall result in the failure of acceptance of the system TAB report. The TAB contractor shall then be responsible to rebalance the system, provide a new system TAB report, and repeat random verifications of the new TAB report. Selected data to be verified will be made known upon day of testing.

Resources

Organizations That Have Programs For Commissioning Professional Certification:

- > ACG: AABC Commissioning Group. <http://www.commissioning.org/membershipcertification/certificationrequirements.aspx>
- > AEE: Association of Energy Engineers. <https://www.aeecenter.org/certifications/certified-building-commissioning-professional>
- > ASHRAE: American Society of Heating, Refrigerating and Air-Conditioning Engineers. <https://www.ashrae.org/education-certification/certification/bcxp-building-commissioning-professional-certification>
- > BCA: Building Commissioning Association. <http://www.bcx.org/certified-commissioning-professional-certification/>
- > BCCB: Building Commissioning Certification Board. <http://bccbonline.org/ccp/>
- > NEBB: National Environmental Balancing Bureau. http://www.nebb.org/nebb_announces_new_process_commissioning_certification/

For further reading:

- > Washington State Department of Enterprise Services: <http://www.des.wa.gov/services/facilities/Energy/Commissioning/Pages/default.aspx>
- > Energy Design Resources: <http://energydesignresources.com/resources/publications/design-guidelines/design-guidelines-commissioning-guidelines.aspx>
- > Checking Economizer Operation: http://www.energy.wsu.edu/documents/AHT_Economizers%5B1%5D.pdf
- > California Commissioning Collaborative: www.cacx.org
- > Whole Building Design Guide: <http://www.wbdg.org/project/buildingcomm.php>